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METHOD AND APPARATUS FOR HANDLING WASTE MATERIAL

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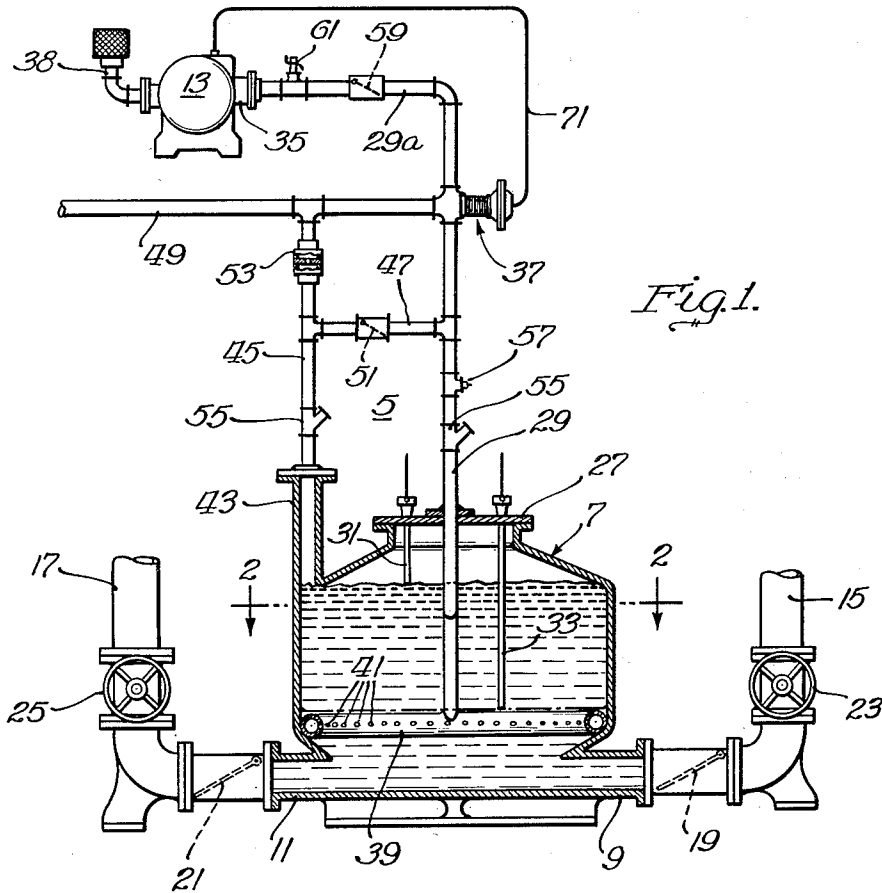


Fig. 1.

Fig. 2.

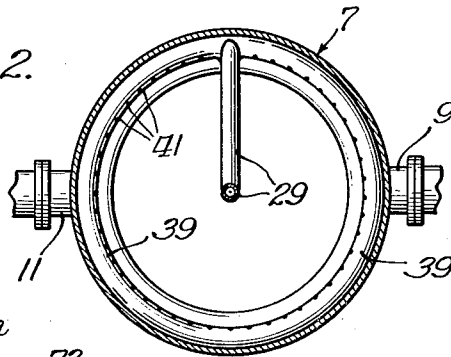
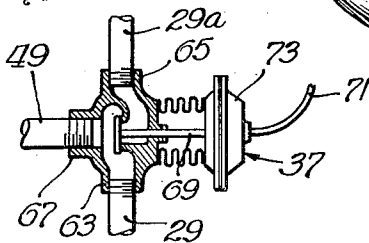


Fig. 3.



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METHOD AND APPARATUS FOR HANDLING WASTE MATERIAL

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The present invention relates generally to the handling of waste materials and is particularly directed to improved methods and apparatus for handling and for pumping fluid waste materials.

In the operation of various types of sewerage systems, it is frequently necessary to collect waste materials over a period of time and then pump such materials into a main or to a disposal point. This results chiefly because of the highly variable loads which are encountered in the operation of these systems and the inability of known pumping mechanisms to accomplish efficiently continuous operation when subjected to variable loads.

A highly satisfactory solution to the above problem consists in the provision of gas displacement type ejectors, such as that shown in the Yeomans Patent No. 2,644,405. These mechanisms are operable to collect substantial quantities of waste material and then discharge the collected material under pressure into the force main of the sewerage system. They operate quite automatically regardless of the rate of loading and generally give reliable, trouble-free service.

However, there is another problem in the handling of sewage, particularly when it must be held in a collecting vessel, such as a gas ejector, for what may be substantial periods of time. This latter problem involves the development in such collected fluids of septic and acidic conditions. These conditions are evidenced by the production of noxious odors, by corrosion of the ejecting equipment and conduits and, of even greater importance, by impairment of the normal treating processes at a later point in the system.

The present invention is concerned with the overcoming of these conditions which have been accepted heretofore as a necessary evil in the operation of pumping equipment, and especially gas displacement ejectors, when waste materials must be collected and held for varying periods of time. As will hereinafter appear, this object is accomplished by providing means whereby gas displacement ejectors can be operated so as to provide effective and positive aeration of the contents of such mechanisms as an incident to their normal operations. More specifically, this invention provides a combination pneumatic ejector and pressure aerator, which is effective to dissolve oxygen in the sewage in the ejector during the discharge cycle of the ejector, at a rate and in an amount sufficient to substantially reduce the immediate oxygen demand existing in the waste material being handled by the ejector, thereby to reduce development of septic and acidic conditions in such material.

A further object of the invention is to provide means for dissolving oxygen in the fluid waste material contained in a pneumatic ejector, which is relatively inexpensive and which may be readily placed in existing ejector installations. Other objects and advantages will become apparent as the disclosure progresses with respect to the accompanying drawings, wherein:

FIG. 1 is a schematic illustration of a pneumatic ejector installation embodying the principles of the present invention.

FIG. 2 is a sectional view taken along the line 2—2 in FIG. 1.

FIG. 3 is an enlarged view, partly in section, of the diaphragm valve shown in FIG. 1.

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Before proceeding with a description of the apparatus chosen to illustrate the present invention, it is believed desirable to further discuss some of the characteristics of sewage material and the problems involved in the handling of such material. As indicated above, the raw sewage which is normally collected at pumping stations has a characteristic biological oxygen demand existing in the form of an immediate demand and, also, a more delayed or ordinary demand. The actual quantitative amount of each of these two phases of biological oxygen demand varies considerably depending upon the nature of the material comprising the sewage, but the ultimate problem in treating any sewage is to reduce the biological oxygen demand (B.O.D.) to a value such that it will be safe for passage into a stream without danger of adversely affecting subsequent stream usage.

In the usual waste disposal system the sewage is treated by biologically active means, such as aerobic carbonaceous bacteria and nitrifying bacteria, which require oxygen for their continuing and useful existence. Consequently, the existence of an unsatisfied immediate oxygen demand in the sewage is highly detrimental to the growth of such bacteria and must be accommodated before the sewage is exposed to such biologically active means. This pre-treatment of the sewage is, of course, an additional economic factor in the treatment of sewage.

Furthermore, the presence in the sewerage system of sewage having an unsatisfied immediate oxygen demand tends to produce a septic condition which is accompanied by noxious odors in the area of the lift stations, as well as in the region of any force mains which are fairly close to the ground surface. Then too, such sewage is often acidic and has a corrosive effect on metal parts and has been known to destroy both metal and concrete conduits.

With reference now to the drawing, it is seen that the apparatus chosen to illustrate the principles of this invention is in the form of a pneumatic ejector 5 comprising a receiver 7 having a fluid inlet passage 9 and a fluid outlet passage 11, and an air compressor unit 13 which provides the source of pressure air for the ejector. The receiver inlet 9 is connected to a conduit 15 which delivers waste material to the ejector, and the outlet passage 11 is connected to another conduit 17 through which the waste material is discharged under pressure to a force main or other means of further disposing of the fluid waste. Suitable check valves 19 and 21 are disposed in controlling relation to receiver inlet 9 and outlet 11, respectively, to prevent a reverse flow of the sewage being handled by the ejector 5. In addition, a pair of manually controlled valves 23 and 25 are placed in the intake and discharge conduits 15 and 17, respectively, for use in the event it is desired to repair or replace the ejector unit.

The receiver 7 of the illustrated apparatus is generally cylindrical and includes a dome-shaped top portion which has a removable central cover plate 27 through which extends an air pipe 29 and a pair of electrodes 31 and 33. The pipe 29 provides fluid communication between the receiver 7 and the pressure outlet 35 of the air compressor 13, subject to the control of a three-way diaphragm type valve 37 which is also shown in detail in FIG. 3. The filtered intake for the compressor is indicated by the numeral 38. The electrodes 31 and 33 are suitably connected to the electrical control circuit for the electric motor which forms a part of the compressor unit 13, so that the circuit will be completed to start the compressor motor when the level of the liquid in the receiver reaches the shorter electrode 31. Similarly when the liquid waste material is reduced to a level below the longer electrode 33, the circuit to the motor will be

broken and the operation of the compressor unit will be stopped.

As seen also in FIG. 2, the lower end of the air pipe 29 terminates in an annular conduit portion 39, which is preferably disposed below the low liquid level, defined by the long electrode 33, and along the wall of the receiver. The annular conduit 39 is provided with many small openings 41 therethrough along the surface portions which face toward the center of the receiver. Consequently, the pressure air discharged by the compressor 13 into the receiver 7, through the pipe 29 is diffused through the fluid waste material in the receiver adjacent the bottom and over a relatively large area.

The receiver 7 also includes a vent 43 to permit the escape of air in the receiver to the atmosphere, in order that the receiver might thereby fill with the waste material flowing through the conduit 15 into the inlet 9. The vent 43 has connected thereto a pipe 45 which communicates with the pipe 29 through a branch 47 and which also extends to a connection with a vent pipe 49 having communication with the atmosphere. The branch line 47 between the pipes 45 and 29 includes a check valve 51 to prevent the flow of pressure air therethrough as it flows to the receiver through pipe 29. The portion of pipe 45 which extends above the branch 47 and is connected with the vent pipe 49 includes a restricted orifice fitting 53 which provides for a metered flow of air through that portion of pipe 45.

Each of the pipes 45 and 29 may also include a suitable trap 55 provided with a screen for preventing the back flow of solid materials through these pipes. Furthermore, the pipe 29 is preferably provided with a suitable check valve 57, located downstream of control valve 37, to prevent the back flow of fluid waste materials, as well as a check valve 59 in the upper portion of the pipe 29, indicated as 29a, to prevent a back pressure on the compressor. There may also be provided a safety valve 61 in the line 29a adjacent the pressure outlet 35 of the compressor to prevent the building up of an excessive pressure in this line.

It is seen from the foregoing that, apart from the restricted vent provided through the orifice 53, all of the air communication with the receiver 7 is controlled primarily by the diaphragm type valve 37. As noted particularly in FIG. 3, the valve 37 is of a known type having a main body with threaded openings 63, 65 and 67 for receiving the pipes 29, 29a and 49 respectively. A plunger 69 is fixed to the diaphragm portion of the valve for movement therewith from the position shown, blocking communication between the compressor and the receiver and placing the latter in communication with the atmosphere through pipes 29 and 49, to a position placing the compressor 13 in fluid communication with the pipe 29 and closing the opening 67 to the vent pipe 49.

For operating the diaphragm portion of valve 37 and, consequently, the plunger 69, there is provided an air line 71 which places the diaphragm housing portion 73 in communication with a cell of the positive displacement vane-type compressor 13 in the manner fully described in the Yeomans Patent No. 2,385,905. Thus, when the compressor is not operating the plunger is in the retracted position shown in FIG. 3 providing fluid communication between the receiver and the atmosphere through vent 43, pipe 45, branch pipe 47, the main air pipe 29 and the vent pipe 49. When the compressor is operating, pressure air is bled off through the line 71 to move the plunger 69 to its extended position, closing off the opening 67 to the vent pipe 49 and permitting a flow of air from the pipe section 29a to the pipe 29 and thence to the receiver.

Assuming that the waste material flowing through the intake pipe 15 has filled the receiver 7 to the level of the short electrode 31, there is thereby established a contact between the two electrodes to complete the circuit of the compressor motor and thereby operate the

compressor 13. Sufficient pressure from one cell of the compressor is bled off through the line 71 to operate the diaphragm valve 37 and extend the valve plunger 69. This movement of the valve plunger establishes communication between the compressor and the receiver 7 through the pipes 29a and 29.

The pressure air enters the receiver at the lower liquid level through the small openings 41 in the ring-like conduit portion 39 and is thereby rapidly diffused through the liquid-borne waste material. The entrance of the pressure air into the receiver creates a pressure head on the fluid waste which acts to close the intake check valve 19 and to open the discharge check valve 21. The fluid waste material in the receiver is thus discharged into the conduit 17 until the level in the receiver falls below the long electrode 33. At this point the electrical circuit controlling the compressor motor is broken and the operation of the compressor ceases. As the compressor stops operating the resulting loss of pressure in the line 71 to the control valve 37 affords a retraction of the plunger 69 to open the port 67 and thereby vent the receiver to the atmosphere through pipes 45, 47, 29 and 49 and permit it to fill.

It will also be noted that during the discharge cycle, as pressure air flows into the receiver, a portion of the pressure air will initially enter the branch pipe 47 and close the check valve 51. However, a predetermined amount of the air which is dispersed in the fluid waste in the receiver through the openings 41 will escape to the atmosphere through the restricted orifice 53 and the line 49. The amount of air which escapes in the latter manner will, of course, depend on the size of the orifice 53 and on the discharge pressure head in the receiver.

Thus, during the discharge cycle of the ejector there is established a dispersal of the pressure air over a large area of the bottom portion of the receiver, as well as a controlled escapement of a portion of such air as it rises above the level of the fluid waste in the receiver. The effect of the described action of the pressure air is to disperse a large number of very small air bubbles throughout the fluid waste and, as these air bubbles pass upwardly through the waste, a substantial quantity of oxygen from the air is dissolved into the fluid waste for satisfaction of the above-described immediate biological oxygen demand.

It is seen, therefore, that the described manner of discharging the fluid waste from the receiver 7 provides also for dissolving oxygen into the waste to satisfy some or all of the immediate oxygen demand. Furthermore, it has been determined by experimentation that the mere introduction of air into the receiver does not afford a similar result, and that in such instance there is a negligible gain in the amount of oxygen dissolved in the waste. It appears that it is necessary to bleed a controlled amount of air from the receiver while pressure air is being introduced, in order to achieve any effective gain in the amount of dissolved oxygen (D.O.) in the waste material. In other words, the pressure air must be introduced in such a manner that a greater amount of pressure air is delivered into the receiver than would be required in the absence of any venting of the receiver, thereby increasing the amount of oxygen that is made available to the fluid waste material during the injection period.

As a result of tests conducted with apparatus embodying the principles of this invention, it has been demonstrated that for any given quantity of fluid waste material the total amount of dissolved oxygen gain during a discharge cycle of a definite period of time is a function of the discharge pressure head in the receiver and the amount of free air bled through the restricted orifice 53. Furthermore, the D.O. (dissolved oxygen) gain apparently becomes fairly well stabilized under a given discharge head at a particular flow of free air through the restricted orifice, and no substantial additional D.O. gain is had by

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further increasing the quantity of air being bled off from the receiver.

For example, in using an ejector of the type described having a discharge capacity of 150 gallons and a discharge cycle of 30 seconds, tests were conducted under discharge heads of 10, 15 and 20 pounds per square inch, respectively, wherein the amount of air bled off during the discharge cycle was varied. An average of the results obtained in each test were as follows:

Test No. 1 (10 #/sq. in.)		Test No. 2 (15 #/sq. in.)		Test No. 3 (20 #/sq. in.)	
D.O. gain p.p.m. ¹	Air bleed-Off cubic feet	D.O. gain p.p.m.	Air bleed-Off cubic feet	D.O. gain p.p.m.	Air bleed-Off cubic feet
3.28	2.4	5.00	3.5	5.50	3.0
3.70	3.4	5.70	4.3	5.75	4.0
4.00	3.5	6.00	5.2	5.90	4.9
4.16	4.4	6.00	7.5	6.30	6.0
4.20	5.5			6.20	8.2
4.20	6.5				

¹ Parts per million.

It appears from the foregoing results that there is probably a maximum D.O. gain obtainable with a given discharge head and that such gain cannot be appreciably enlarged by increasing the flow of air through the bleed-off orifice. Tests #2 and #3 further indicate that probably for a given size ejector there may be no advantage gained by increasing the discharge pressure head beyond a certain amount, insofar as the D.O. gain realized is concerned.

However, it should be noted that the above tests are merely representative of the advantages afforded by the present invention, in showing an appreciable gain in dissolved oxygen in the sewage. The results of these tests are not intended to be conclusive with respect to the utility or scope of this invention.

It is important to note that with relatively little experimentation as to the possibility of further increasing the efficiency of the test apparatus by redesigning certain parts, a dissolved oxygen gain of over 6 parts per million was achieved under the ordinary discharge head of 15 lbs./sq. in. This D.O. gain is sufficient in many instances to satisfy substantially all of the immediate biological oxygen demand of the waste, and in other cases will be sufficient to substantially reduce the immediate B.O.D. and thereby reduce the heretofore prevailing conditions of septicity and acidity in the receiver as well as in the sewerage mains.

Tests have shown that the pretreatment of the sewage which is provided for in the described ejector apparatus will not only eliminate or substantially reduce the noxious odors generally accompanying such installations, but will add appreciably to the life of the ejector and sewerage mains by minimizing development of the corrosive agents in the sewage. Of equal or greater importance is the fact that the described pretreatment of the waste material also facilitates the final disposal of the sewage by taking care of all or much of the immediate oxygen demand before the sewage reaches the treatment and disposal plant.

Although described with respect to particular apparatus and conditions, it will be apparent to those skilled in the art that the principles of the present invention may also be applied to other types of apparatus and under other conditions and circumstances of waste material treatment.

I claim:

1. A gas displacement type ejector for handling liquid-borne waste materials while affording aerobic treatment of the waste materials as an incident to the ejection of such materials, comprising a receiver having a fluid inlet, a fluid outlet disposed adjacent the lower level of said receiver, means within said receiver for introducing

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pressure air into the receiver adjacent the level of said fluid outlet to eject the liquid-borne waste material through said fluid outlet, means operable to vent said receiver to permit the flow of waste material through said fluid inlet into said receiver to thereby fill the latter to a predetermined upper level, and additional vent means in fluid communication with the interior of said receiver above said predetermined upper level to provide continuous venting of said receiver, said additional vent means comprising a restricted orifice adapted to afford controlled escapement of pressure air introduced into said receiver during the ejection cycle at a rate substantially lower than the rate of flow of pressure air into said receiver, thereby bleeding off a portion of the pressure air from the receiver during the ejection cycle and causing a greater amount of pressure air to pass through said waste materials than would be required without said additional vent means and with the same ejection pressure and cycle.

2. A gas displacement type ejector for handling liquid-borne waste materials while affording aerobic treatment of the waste materials as an incident to the ejection of such materials, comprising a receiver having a fluid inlet, a fluid outlet disposed adjacent the lower level of said receiver, and additional means for introducing oxygen-containing pressure gas into the receiver adjacent the level of said fluid outlet after the receiver is filled to said upper level, to thereby eject the liquid-borne waste material through said fluid outlet, means operable to vent said receiver to permit flow of waste material through said fluid inlet into said receiver to fill the latter to a predetermined upper level, vent means in fluid communication with the interior of said receiver above said predetermined upper level to provide venting of said receiver during the ejection of the waste material, said additional vent means comprising a restricted orifice adapted to afford controlled escapement of said pressure gas from said receiver at a rate substantially lower than the rate of flow of pressure gas into said receiver, thereby bleeding off a portion of the pressure gas from the receiver during the ejection cycle and causing a greater amount of pressure gas to pass through said waste materials than would be required without said additional vent means and with the same ejection pressure and cycle.

3. A method affording aerobic treatment of the bacteria in liquid-borne waste material while displacing the waste material from a collecting station, comprising the collecting of a predetermined quantity of said waste material in a closed receiver having a fluid outlet adjacent the lower portion thereof, and introducing pressure gas including available oxygen into the receiver to displace the waste material in the receiver through the fluid outlet, the pressure gas being introduced into the receiver at a position adjacent the fluid outlet, continuously venting the receiver above the upper level of the waste material while introducing said pressure gas and in a manner affording the escapement of gas at a rate substantially lower than the rate of flow of said pressure gas into the receiver, whereby the quantity of pressure gas required to eject the waste material from the receiver during a given time interval is increased and such greater quantity of pressure gas is caused to pass through the waste material during substantially the entire ejection cycle to thereby facilitate dissolution of oxygen into said waste material.

4. A method affording aerobic treatment of the bacteria in liquid-borne waste material while ejecting the waste material from a pneumatic displacement type ejector having a fluid outlet adjacent the lower portion of the receiver portion of the ejector, comprising the collecting of a predetermined quantity of said waste material in the receiver, and introducing pressure air into the receiver at a position adjacent the fluid outlet for ejecting the material through the outlet while continuously venting the receiver above the upper level of the waste

material collected therein in a manner affording the escapement of air at a rate substantially lower than the rate of flow of said pressure air into the receiver, whereby the quantity of pressure air required to eject the waste material from the receiver during a given time interval and at a given unit pressure is increased and such greater quantity of pressure air is caused to pass through the waste material during substantially the entire ejection cycle to thereby facilitate dissolution of oxygen into said waste material.

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